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MODIFICATIONS AND TEST PROCEDURES FOR THE STOCKSTAD-LORY IGNITION FURNACE

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ABSTRACT

Ignition studies of such fine forest fuels as needles, rotten wood, and grass have been hindered by the lack of a suitable ignition-producing device and a reliable test procedure. Ignition tests were conducted at the Northern Forest Fire Laboratory on a variety of fuels. As a result of these tests, a standardized procedure was adopted and modifications were made to the Stockstad-Lory ignition furnace that overcame these difficulties.

A new ignition boat was designed and a stationary thermocouple was introduced for monitoring the ignition chamber temperatures. The test procedures adopted considered operator reaction time, introduction of the ignition boat in the isothermal ignition chamber atmosphere, the position of the pilot flame, and the effect of its introduction into the ignition chamber.

KEY WORDS: IGNITION, IGNITION FURNACE, FOREST FUEL IGNITION, PILOT IGNITION, SPONTANEOUS IGNITION.

The fire hazard associated with many forest and rangeland fuels is related to the ignitibility of the fine fuels. The Northern Forest Fire Laboratory Fuels Science research work unit developed a specially designed ignition furnace to study the ignitibility of these fuels.[2]

Ignition studies are hampered by the number of variables existing within any ignition-producing device and the selected test procedure, which makes securing a consistent temperature relationship between the ignition furnace, the boat assembly, and the fuel particle difficult. These variables may be classed into three categories: (1) The fuel, (2) the furnace, and (3) the test procedure.

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[2]D. S. Stockstad and E. C. Lory. A forest fuel ignition furnace. USDA For. Serv. Res. Note INT-122, 7 p., illus. 1970.

Variables like fuel size, shape, and moisture content can usually be controlled by the test operator. Chemical composition of the fuel particle may vary with location and time of collection[3] [4] but is assumed constant within a species collected from a given time and location.

The ignition furnace is a source of several variables. Some are controllable while others must be compensated for by adjusting testing procedures.

If a fuel particle is to be tested in an isothermal environment, this environment must have a similar temperature for each particle. The temperature of the furnace drops suddenly when the fuel particle and its holder are inserted into the furnace. This temperature drop can be assumed constant for all tests if the ignition boat and the fuel particle size are held constant. Introducing a pilot flame into the heated environment changes the temperature. (It also may be assumed constant for all tests if a given flame length and distance from the test sample are held constant.)

The results of ignition tests are affected by several operations in handling the sample. Variation of the cycle time between samples produces a corresponding variation in the furnace temperature and pattern of ignition. The time required to place thermocouples on the sample, load the sample onto the ignition boat, and insert the boat into the furnace all affect cycle time. Placement of the thermocouple on the sample and in the furnace must be carefully duplicated for each sample to obtain consistent results.

We developed a more feasible approach; that is, we assume the furnace temperature will change upon insertion of the sample, but this rate of change will be constant for all samples. The problem then becomes one of establishing a procedure to insure uniform temperature change rather than eliminating temperature change. This approach required minor modifications to the original furnace.[5]

FURNACE DESIGN MODIFICATIONS

The use of a thermocouple on the ignition boat assembly to measure ignition chamber temperature required an excessively long wait between tests for the mass of the boat to come to equilibrium with the ignition chamber. We eliminated this problem by installing a stationary thermocouple probe through the exhaust stack into the ignition chamber. This thermocouple was placed adjacent to thermocouples on the ignition boat assembly and positioned so all three thermocouples registered the same temperature when the system reached equilibrium (fig. 1). The stack thermocouple was then used to measure the control temperature for all tests.

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[3]Charles W. Philpot and R. W. Mutch. The seasonal trends in moisture content, ether extractives, and energy of ponderosa pine and Douglas-fir needles. USDA For. Serv. Res. Pap. INT-102, 21 p., illus. 1971.

[4]Charles W. Philpot. Seasonal changes in heat content and ether extractive content of chamise. USDA For. Serv. Res. Pap. INT-61, 10 p., illus. 1969.

[5]See footnote 2.

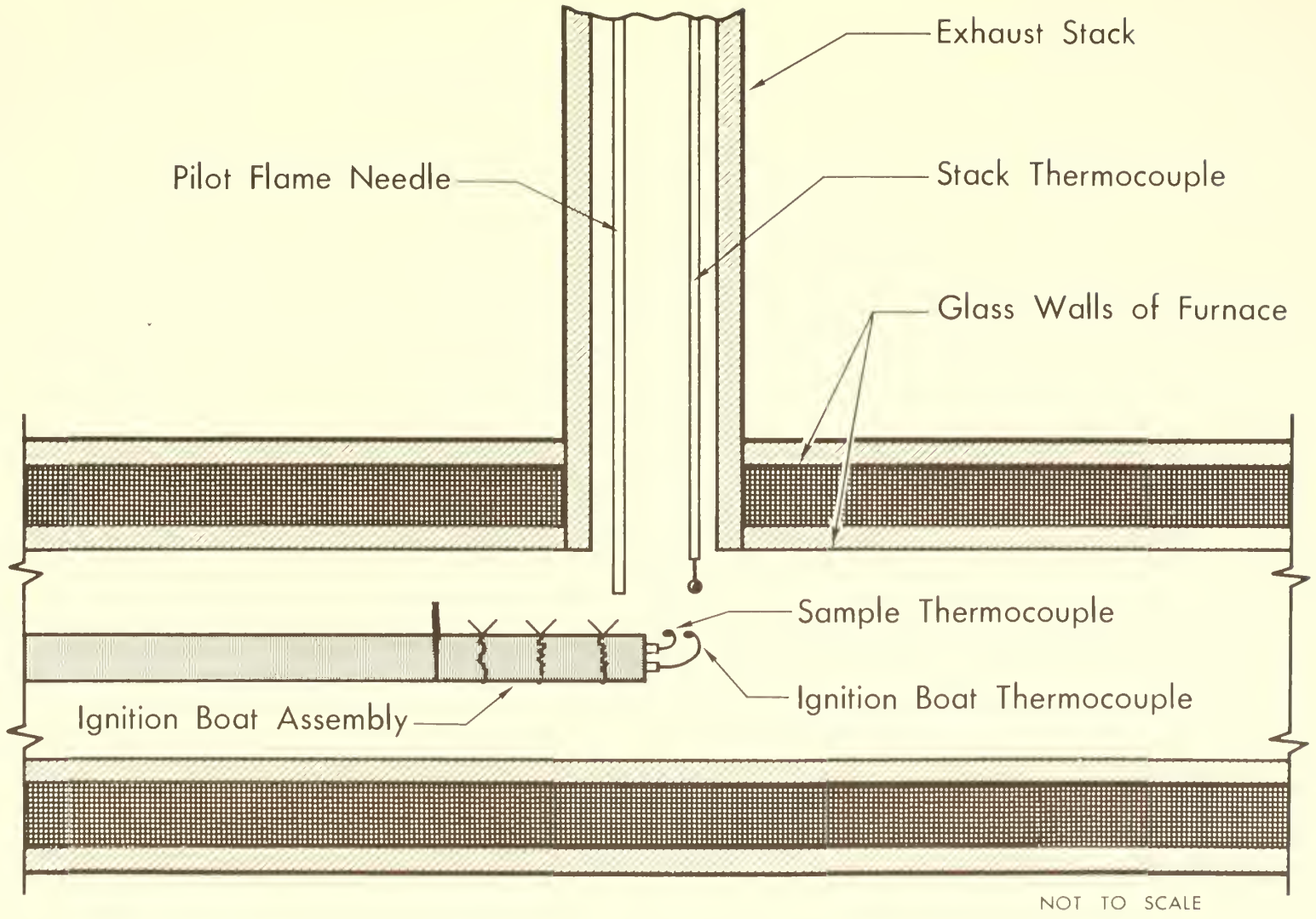

Figure 1.--Thermocouple placement in ignition chamber of Stockstad-Lory ignition furnace.

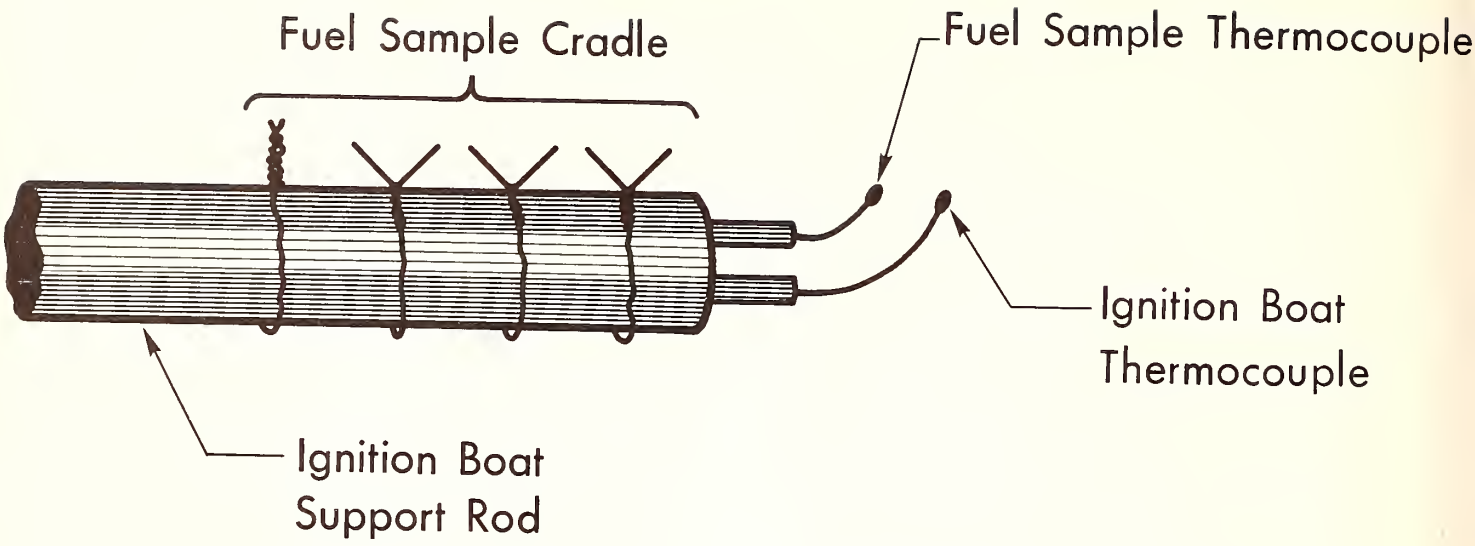

Figure 2.--Ignition boat assembly for Stockstad-Lory ignition furnace.

The clip-type ignition boat assembly was modified to provide a successful fuel particle holder for a variety of fuels (fig. 2). Number 28-gage thermocouple wire was used to form a cradle in which the fuel was placed. This cradle-type holder introduced less mass into the controlled temperature atmosphere.

TEST PROCEDURES

Procedures for spontaneous and pilot ignition tests were quite similar. The tests began with the ignition boat inside the furnace. The heating units of the furnace were adjusted to the desired temperature on the stack thermocouple and the ignition boat thermocouples. The ignition boat assembly was quickly withdrawn from the furnace. A fuel particle was placed on the holding cradle and immediately re-inserted into the furnace. Ignition time and temperatures were recorded and the stack thermocouple was monitored to determine when the ignition chamber had reattained the desired test temperature. The test cycle was then repeated.

The time required to withdraw the ignition boat, load the fuel particle, and reinsert the boat assembly were variables in this test procedure. But with experience, an operator can achieve a rhythmic motion and approach a constant value for all tests.

Pilot ignition tests followed the same sequence of procedures used in spontaneous testing except for a pilot flame in the ignition chamber. The effect of the flame on the ignition chamber temperature was determined by varying the distance between the tip of the 2-mm. pilot flame and the base reference point. The base reference was a 0.076- by 1-inch piece of metal rod placed on the ignition boat cradle. This metal rod had the same dimension as the fuel particles tested. The pilot flame length of 2 mm. was obtained by lowering the tip of the hypodermic needle on the pilot flame assembly until it touched the reference rod; the needle was backed off 2 mm. and the flame was adjusted to touch the reference rod.

The distance between the pilot flame and the reference rod was varied from 5 to 10 mm. Temperatures of the ignition chamber thermocouples were monitored for each position (fig. 3). The pilot flame raised the ignition chamber temperature by 9° C. in the 5-mm. position, and 0° at the 9- and 10-mm. positions.

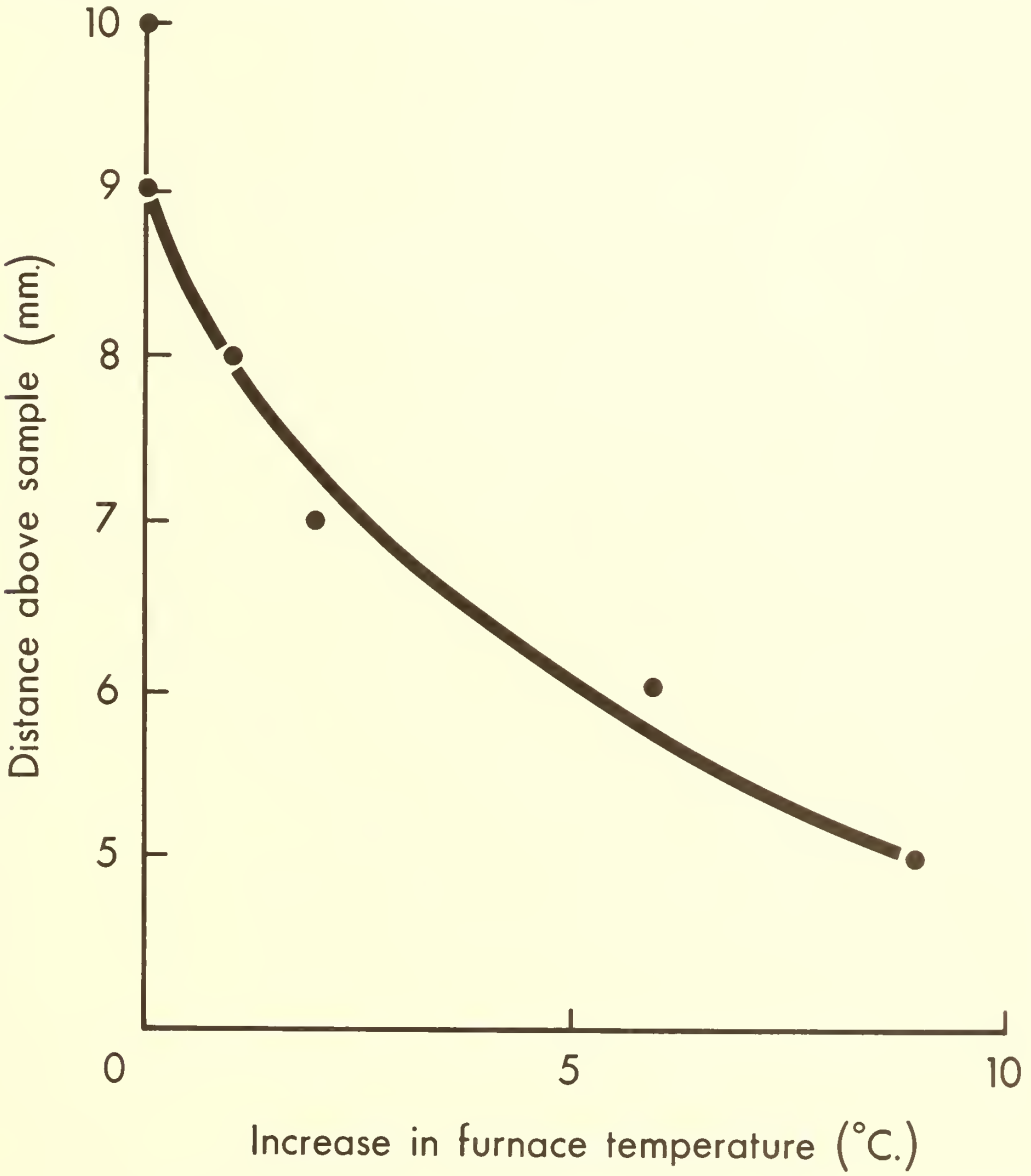

Figure 3.--Effect of pilot flame position on ignition chamber temperature in Stockstad-Lory ignition furnace.

The optimum position of the pilot flame for igniting volatiles from the samples was determined in a similar manner. The temperature of the ignition chamber was raised sufficiently to insure ignition of all samples if the volatile stream was in the proper concentration at the time of contact with the pilot flame. The position of the pilot flame was varied from no-sample ignition to 100-percent ignition (fig. 4).

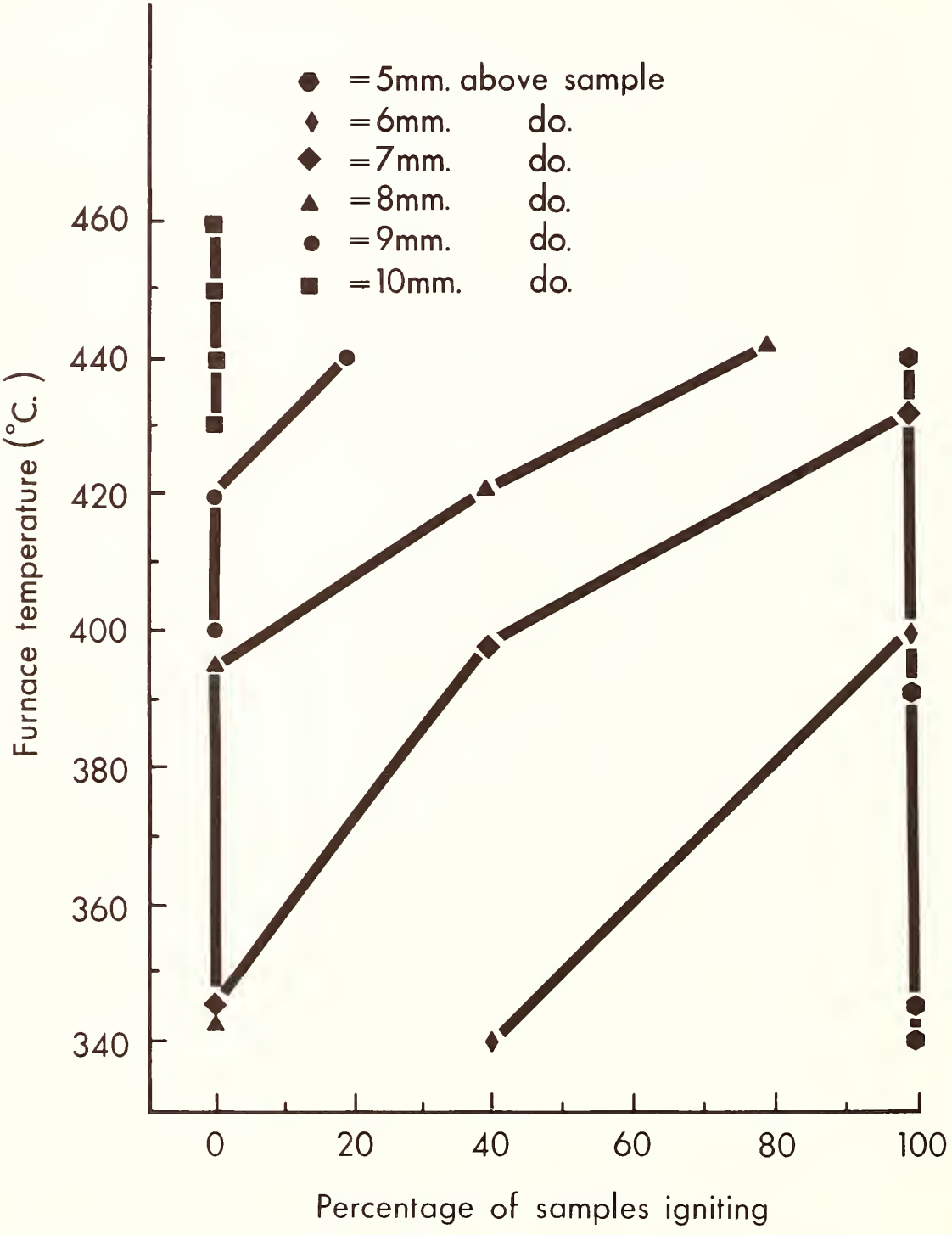

Figure 4.--Effect of pilot flame position on ignition process in Stockstad-Lory ignition furnace.

The maximum distance at which 100-percent ignitions occurred for all furnace temperatures tested was 5-1/2 mm. above the sample. No ignitions occurred at a position 10 mm. above the sample. Based on these results, the pilot flame was positioned 5-1/2 mm. above the test samples. This distance insured pilot ignition if the heat flux from the furnace was of sufficient magnitude and if volatiles from the sample were present in proper concentrations to support ignition.

Inasmuch as variation in sample size may necessitate a change in placement of pilot flame, fuels other than those we have tested (pine needles, cheatgrass stems, and rotten wood sections) may have a different pilot flame-to-sample relationship. As new fuels are tested, the procedure for optimum pilot flame placement should be followed. These tests are continuing at the Northern Forest Fire Laboratory.

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